cause or location, except in direction, of the *gegenschein*, but it seems not improbable that it may be more distinctly visible during the passage of the earth through the luminous particles of a comet's tail, and therefore it should be studied, at the proper time, with the greatest care by those in the habit of observing it.

18. *The Auroral Line.*—Arrhenius[5] says:

Whichever way we turn the spectroscope on a very clear night, especially in the tropics, we observe this peculiar green line. (The so-called auroral line.) It was formerly considered to be characteristic of the zodiacal light, but on a closer examination it has been traced all over the sky, even where the zodiacal light could not be observed.

Evidently the source of this line is not definitely known, but, conceivably, it may be rendered more brilliant by the passage of the earth through the tail of a comet, and therefore it would be well for some favorably situated observer carefully to measure its brilliancy on several consecutive nights, so selected as symmetrically to overlap the calculated date of our supposed passage through the tail of Halley's comet.

The most promising, in this connection, of the above phenomena are, in the author's opinion, those designated as *a, b, c, d,* 5, 6, 9, 10, 13, 16 and 17.

The above is not claimed as a complete list of the phenomena that may be associated with a comet, but it is hoped that they, together with others that they may suggest, will soon give us a better understanding of comets in general and of Halley's in particular.

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SPECIAL ARTICLES

SOME LONG-PERIOD DEVIATIONS OF THE HORIZONTAL PENDULUMS AT THE HARVARD SEISMOGRAPHIC STATION

The studies of Omori, Milne, Denison and many others, on the movements of horizontal pendulums due to other than seismic or microseismic causes, suggested a similar study of the movements shown by the pair of Bosch-Omori instruments at the Harvard station. These pendulums, which stand at right angles to each other on the meridian and parallel of the station, record through small tracers on sheets of smoked paper carried by drums that complete a revolution once in an hour. The drums travel laterally, causing each hour's record to appear as a single line spaced about an eighth of an inch from its neighbor on either hand. A complete day's record, undisturbed by seismic or other movements, appears as a series of twenty-four parallel lines. Any long-period deviations of the pendulums, therefore, are shown by a crowding of these lines toward one side of the sheet or the other.

The study was made to determine whether or not solar or cyclonic and anticyclonic conditions affect the pendulums, as has been suggested. Lack of time prohibited an investigation of tidal and other effects, except so far as to prove them entirely subordinate to the main controls. The records were examined for the months of April, May, October, November and December, 1908. The pendulum standing on the meridian of the station (the east-west component, so-called) is most sensitive, in the matter of long, non-periodic movements, to forces applied due east or west of the station. The same is true of the north-south component in reference to forces applied on the north or south.

Two types of deflection are shown by each component:

The E.-W. Component: Type 1.—A diurnal deflection. This is indicated by a more or less strong tendency of the pendulum to move east during the forenoon and west later in the day. It begins about sunrise, the more or less steady easterly travel dying out about noon and later becoming a westerly travel which often lasts well into the night. This type of deflection never persists from one twenty-four hours into the next; it occurs only on days when the sun shines, and is best shown on the least cloudy days. When the diurnal quality of the thermograph curve is most marked, the pendulum

[5] "Worlds in the Making," p. 116.

records the strongest diurnal deflection. Some kind of solar control seems necessary to explain these movements. The method of its action has not been made out.

Type 2.—Correlation of the movements of the pendulum with the movements of areas of low and high barometric pressure across the United States and southern Canada, shows an intimate relation between them. An easterly deflection of the E.-W. component begins when an area of low pressure appears in some westerly or southwesterly direction from the station. The cyclone may be even 1,500 or more miles away when the deflection begins. The time of beginning seems to depend partly on the movements of a high-pressure center to the east, though such a relation can not be definitely worked out until more complete knowledge of conditions over the Atlantic Ocean is available. There appears to be at least a general relation between the amount of pressure at the center of the cyclone, the area covered by it, the rapidity of its movement, and the time of beginning and the rapidity of easterly travel of the pendulum. As the depression moves east or northeast, the pendulum also moves toward the east until the cyclone is nearly over the station, and as the depression passes off the coast, the pendulum begins to travel toward the west. Inspection of the current weather map shows an area of high pressure, or one of less intense low pressure, than that which caused the deflection, to be approaching easterly in the western quadrant. As the anticyclone comes nearer, the westerly travel usually increases in rapidity. When the center is approximately over the station, the direction of travel is reversed and the cycle repeated. These deflections occupy any length of time, dependent wholly on the time taken for the passage of the cyclone or anticyclone. They often begin many hours before the barometer indicates the approach of minima or maxima. They do not go on uninterruptedly; there are countless minor variations the causes of which it is as yet impossible to determine. The diurnal deflection is superimposed on these longer, non-periodic deflections.

The N.-S. Component: Type 1.—A diurnal deflection. This is indicated by a more or less strong tendency of the pendulum to move south during the forenoon, and north later in the day. It is much less clearly shown than the diurnal of the E.-W. component, and is apparently dependent on the same causes.

Type 2.—Deflections cyclonically or anticyclonically controlled. These include all movements due to the approach of high or low pressure areas from some westerly direction. They are somewhat less frequent, and usually much less marked, and their period of maximum activity is nearly always much shorter than is the case with the deflections of the E.-W. component. This is apparently due to the parallelism of the N.-S. component to the mean cyclonic and anticyclonic tracks. The approach of a *high* from the northwest and its passage north of the station, or the approach of a *low* from the south or southwest and its passage south, is accompanied by a northward deflection of the pendulum. This reaches its maximum when the pressure gradient runs due north, and becomes a southerly deflection when pressure conditions are reversed. Often interrupting these deflections are temporary movements for a few hours in a contrary direction, followed by the renewal of the long-period travel. These variations do not affect the general tendency, and their causes have not been made out. The diurnal deflection is superimposed on these longer, non-periodic deflections.

The summary presented in the table below shows for each component the per cents of cases (on the basis of numbers of days out of the total) in which the particular deflection occurred. A more desirable basis would be units by cyclones and anticyclones; but the variability of the time taken for the passage of these areas by the station, their complex distributions, and the impossibility of evaluating the share that each has in producing a given deflection, makes it impracticable to determine the limits of any one unit. The per cents. of movements from *lows* toward *highs* are considerably smaller than they would be if computed on the latter basis, for they take

account of temporary reversals in deflection which are lost sight of in the general deflections lasting for an indefinite period.

	E.-W. Component.		N.-S. Component.	
	Deflection from *Lows* toward *Highs*	Deflection from *Highs* toward *Lows*	Deflection from *Lows* toward *Highs*	Deflection from *Highs* toward *Lows*
April......	70.0 %	30.0 %	55.0 %	45.0 %
May.........	95.2	4.8	69.5	30.5
October....	94.7	5.3	62.5	37.5
November.	83.3	16.7	77.7	22.3
December.	100.0	0.0	85.7	14.3
Mean.......	88.5	11.5	69.0	31.0

It will be noticed that the pendulums show greater response to pressure conditions during the fall and winter months than during the spring months. This is to be expected, inasmuch as barometric maxima and minima are best developed during fall and winter. The records for the summer months were not examined critically on this account. The study thus far has been entirely qualitative; quantitative work has been found unsatisfactory owing to the lack of a recording device which shall obviate the running together of the hourly lines at the very frequent times of extreme deflection.

The causes of the movements here described are obscure. Many suggestions regarding the causes of similar movements elsewhere have been made, but no one of them is corroborated as yet by sufficiently wide-spread observation, to warrant its being fully accepted. It would seem that causes which may be operative over long distances must be assumed, for the pendulums at Cambridge show distinct movements in sympathy with barometric maxima and minima when these are still very far distant from the station.

The possibility of using horizontal pendulums in forecasting on windward coasts has been suggested by Mr. F. Napier Denison, of the Meteorological Office at Victoria, B. C. If, as in the case of the Harvard station, horizontal pendulums in general announce the approach of various pressure conditions in advance of the barometer, the use of simple instruments of this type in situations where maps of weather conditions to windward are not available, might lead, especially in the latitudes of the prevailing westerly winds and cyclonic storms, to valuable results.

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A SIMPLE AND EFFICIENT LECTURE GALVANOMETER ARRANGEMENT

In view of the extensive use to which the lecture galvanometer is nowadays put in physical and other laboratories, I have been induced to describe a particularly simple arrangement which has been thoroughly tested and whose performance leaves little to be desired.

In this arrangement a firm tripod, supported by a convenient shelf on one wall of the lecture room, carries a 90° arc lamp clamped by a right-angle piece to its vertical rod. The lamp is mounted with the positive carbon vertical, and its luminous tip, the source of light, uppermost. On a wall bracket a converging lens with its axis vertical is mounted about a meter above the arc. The galvanometer, a D'Arsonval instrument with plane mirror, is mounted on a wall shelf with its mirror, *A*, about 0.4 meter above the lens and about 0.1 meter nearer the wall. A second and larger plane mirror, *B*, is mounted with universal adjustments at the edge of the galvanometer shelf. It is fixed vertically above the lens in a horizontal plane a little below *A*. A scale with 2-inch divisions is mounted horizontally near the top of the wall opposite the galvanometer about 9.5 meters away. The galvanometer terminals are permanently connected with binding posts on the lecture table.

When the optical adjustments have been made, light from the tip of the positive carbon, converged by the lens, falls upon the mirror *B* and then upon the mirror *A*, which reflects it to the scale. At the center of the scale a round and brilliant image of the luminous carbon tip is formed. Focal adjustments can be made by moving the lens vertically on its bracket, or the lamp vertically on its rod; and the position of the image on